

DIGITAL

VS.

PNEUMATIC CONTROL

Natural gas pipelines are among the last users of pneumatic controllers, but a more modern digital approach provides many benefits. **Clayton Wilson, Control Instruments Division Manager, Yokogawa Corporation, USA**, provides a comparison of the two different methods.



When the term “pneumatic controls” comes up, the adjective that most commonly precedes it is “antiquated.” Process plants left pneumatic control long ago for the convenience and advantages of electronic digital control. Anyone who has seen the insides of a traditional pneumatic panel board control room can not help but admire the craftsmanship of those tubing fitters of an earlier era, but electronic and digital systems provide capabilities for process tuning, custom control logic and communication that are too valuable to ignore.

At the same time, the availability of pneumatic equipment has declined while prices of these complex mechanical devices have increased. Even traditional pneumatic suppliers such as Foxboro and Bristol have discontinued many product lines, leaving users with fewer options for maintenance or new projects.

One area where pneumatic controllers persist is the gas pipeline industry, and there are some practical reasons why users have not made the switch to digital control. But with additional consideration, one can make the case that digital controllers offer many features that should be very attractive to pipeline operators as they provide benefits that are well worth the conversion.

Pneumatics' last stand

Pneumatic controls have remained in place because they offer some benefits that must be addressed if digital controls are to become more prevalent. The primary reason they are still used on gas pipelines is simple: pressurised gas is available to run the controller. It is (essentially) free, and it does not introduce any additional hazards. Pressure in the pipe is most always available, and if it is lost the controller has nothing to do anyway.

Digital controllers are vulnerable to interruptions in the power supply. Given the remoteness of many pipeline installations, this consideration is often cited as a weakness. Moreover, a pneumatic controller is not affected by lightning, which has caused countless failures in electronic instrumentation installed on pipelines. Last but not least, pneumatic controllers do not introduce an ignition source and are thus rated non-incendive, so they can be used in Class 1 Division 1 environments without a second thought.

Digital devices can replace pneumatics as they have in countless refinery and chemical plant applications, but users have to pay attention to appropriate housing, mounting and other considerations.

Digital control for pipelines

There are a number of arguments in support of digital control in the pipeline applications.

Control strategy

A digital control strategy can include redundant transmitters to read pressure from the gas trains, and pressure can be controlled based on different control schemes which are selected based on the intended goal. Pressure can be controlled based on the high or low transmitter, or the average of the two. Differing transmitters can also be brought into the same unit, such as flow and pressure, allowing control of multiple variables or monitoring of one variable while controlling the other.

Response

Varying flows and pressures in the pipeline, either from upstream or downstream, can cause problems with pneumatic controllers. A large diversion of gas to a new destination can cause a drop in pressure, and the controller may not be able

Table 1. Capability comparison: Pneumatic vs. Digital. Since pneumatic and digital systems are fundamentally different (mechanical vs. electronic), they share few characteristics outside of the most basic control functions.

Function	Pneumatic	Digital
PID loop tuning	Manual tuning	Can be manual or automatic
Control functions	Can be flow or pressure but changing requires hardware reconfiguration	Can be flow or pressure and changed as needed via software and even included in the programming
Power source	Pressure provided by the pipeline, but gas must be released to the atmosphere to function	Requires external electric power, but that can come from a variety of sources
Suitability for hazardous environment	Non-incendive	Can be used with appropriate devices when configured properly
Overall robustness	A mechanical device with moving parts, but immune to electrical disturbances	Can be disrupted by electrical interference or loss of power
Remote access and SCADA connectivity	Not suitable without adding electronic sensors or interface	Easy to add as needed; communicates with RTU
Additional functionality	Limited functionality makes it difficult to add capabilities such as historian, totaliser, etc.	Intelligence native to modern devices makes additional functions a matter of programming
Product availability	Fewer product selection options as commercial viability decreases	Virtually limitless choices of sensors and controllers from many sources



Figure 1. Pneumatic controllers and mechanical pressure gages have no capability to communicate data from remote locations to a central control centre. Gathering information means a trip to the site.

to respond quickly. Digital controllers obviously do not share this disadvantage.

Variables

A digital controller can tune its response to a change in the process in a way that is not possible with a pneumatic unit. Such tuning involves adjusting one or all of the controller's proportional, integral and derivative variables. Once the variables are set they are valid for a particular set of operating conditions. Digital controllers can also monitor process conditions and performance, and then adjust or change control variables to suit operating conditions.

One method for changing these variables is gain scheduling, which involves adjusting the proportional band, or gain, based on a variable in the process such as flow. Maintaining pressure in the pipe at a low flowrate requires different variables than at a high flowrate. Using the flowrate in the pipe to provide a linear adjustment to the gain of the controller provides an effective way to keep the pressure under control regardless of changing demands. PID switching is another method of maintaining control.

With this method, the P, I and D terms can all be changed based on process conditions versus the limitation of adjusting the proportional band alone which is typical of most pneumatic controllers. One should also note that there is not a linear relationship between flow and the tuned variables, so the control variables are only changed if the flow varies from a preset range, allowing the user to focus the best tuning parameters on problem control areas.

Autotuning

Manual loop tuning was part and parcel of the pneumatic control age, but is now largely a lost art. Without expert guidance, tuning a flow or pressure loop can cause unusually long times to reach a desired setpoint or excessive loop oscillations. Most digital controllers employ an autotuning algorithm to set the PID parameters.

When the autotuning mechanism is engaged, a controller will lightly disturb the variable and then observe how the process responds. Based on the dead time, the amount of overshoot and the control period, the algorithm is able to determine the best control variables for that loop. This approach can drastically reduce the amount of time and expertise required to stabilise the loop, and the results are typically excellent.

Control flexibility

Flow and pressure can be controlled from the same unit. In applications where flow is a controlled variable, such as multiple gas pipeline service into a power plant where an uninterruptible fuel supply is required, a digital controller can operate based on flow, and then switch to pressure if a single service is used.

Pressure can also be monitored such that if it exceeds a certain threshold, control can be handed off so that pressure

is the primary variable. This type of control strategy is not possible with a pneumatic unit.

Multiple valves on a train can easily be controlled by a single unit. For example, if gas flow to a specific pipeline branch or customer needs to be turned off, the digital controller can close the lock-up valve when commanded. The lock-up valve can also be disengaged automatically and control restored by issuing a single local or remote command.

Remote access

Direct digital access to a local remote terminal unit (RTU) can provide remote access from a central supervisory control and data acquisition (SCADA) system. The SCADA system can then be used to monitor operation, change setpoints, modify operation modes, etc.

Collecting data is as simple as issuing a command over the digital network connecting the controller to the RTU. In case of RTU failure, or simply to reduce the task load on the RTU, a controller with a direct connection to the process and required built-in control functionality can take over control duties that were being performed by the RTU.

Many controllers can perform basic functions such as pressure and temperature compensation or flow totalisation, leaving the RTU available for other tasks. Necessary calculations that were being carried out by the RTU can now be executed by the controller since it has direct access to the process.

Function such as pressure/temperature compensation or flow totalisation through each train can be easily calculated in the controller, leaving the RTU available for other tasks. In most situations, the controller is better suited for these functions due to its quick response time. Most RTUs are relatively slow, running at 1 - 2 Hz, while a controller can run calculations at 20 Hz.

Conclusion

The ability to perform these important functions can outweigh the potential inconveniences of installing the electrical infrastructure to support a digital controller and instrumentation. While the arguments in favour of pneumatic hardware are still considerable, changing market conditions may simply force the issue as those devices are simply unavailable or too expensive. The potential of losing production due to the inability to find a replacement part for a legacy system could outweigh the cost of upgrading to current digital equipment.

With digital control, features and options preferred in a pipeline application can be implemented easily and modified as required with no real physical change to the process. Direct remote access to the control loop via RTUs and a SCADA system provides a level of remote insight into a loop that is simply not possible with pneumatic equipment.

Pneumatic control has had a long and admirable history, but for many it is time to upgrade to the capabilities of more modern approaches in pipeline applications. 